

mentioned types of measures will be successful in avoiding, minimizing, or mitigating the possible cumulative impacts of commercial, ship-based tourism in the Antarctic Peninsula area. Thus, periodic review and revision of the applicable guidelines and codes of conduct to take account of new information is a necessary and important part of the range of measures that can be taken to avoid, minimize, or mitigate possible cumulative adverse impacts.

7. ASSESSING THE PRACTICALITY OF POSSIBLE MANAGEMENT MEASURES

All possible measures for assessing and avoiding or minimizing the cumulative effects of commercial, ship-based tourism may not be practical to implement. As an example, it would be prohibitively costly to attempt to monitor every site in the Antarctic Peninsula area that might be subject to ship-based tourism, even if baseline information on those sites were already available. When assessing possible management measures, the decision makers must consider the practicality and cost of implementing the measures, as well as the need for management action. Variables that may need to be considered include 1) the likely acceptance of the measure(s) by the Antarctic Treaty Consultative Parties, by IAATO members, and by tour operators not members of IAATO; 2) the ease and economic consequences of implementation; 3) possible alternative measures; 4) the actual and perceived effectiveness of existing measures; 5) the uniqueness or novelty of the site to which the measure(s) would apply; 6) the evidence indicating that a cumulative impact is occurring or likely to occur and that the contemplated measure(s) would prevent, minimize, or mitigate the impact; and 7) the presence of a comparable, similarly accessible site or sites near the site that the management measure(s) would affect.

8. ONGOING RESEARCH AND MONITORING PROGRAMS OF POTENTIAL RELEVANCE

There are several long-term research and monitoring programs being conducted in the Peninsula area that are compiling information potentially useful for detecting the possible cumulative environmental effects of tourism and other activities in the area and changes due to natural factors such as change in climate. They include 1) the Antarctic Site Inventory being carried out by Oceanites, a non-governmental organization; 2) the Antarctic Marine Living Resources (AMLR) Research Program being carried out by the Southwest Fisheries Science Center of

the U.S. National Marine Fisheries Service (NMFS); 3) the Palmer Station Long-Term Ecological Research (LTER) Program being supported by the NSF; and 4) penguin studies at Torgersen Island, and in the Palmer Station area, and at King George Island being supported by the NSF and NMFS. These programs were reviewed during the workshop, and are described below. There are additional programs being carried out or supported by other organizations and countries that likewise may be producing potentially useful information. Because of time and funding constraints, the workshop did not attempt to identify or review all potentially relevant programs.

The Antarctic Site Inventory. The Antarctic Site Inventory began fieldwork in the Peninsula in 1994. This project is operated and managed through Oceanites, Inc., a non-profit research and education organization that was established in 1987 by a former Antarctic expedition leader. The initial objectives of the Inventory were to:

- determine whether opportunistic visits can be used to effectively and economically to detect changes in the physical features, flora, and fauna of sites in the Antarctic Peninsula being visited repeatedly by ship-borne tourists; and
- begin compiling baseline data and activity information necessary to detect and determine the possible causes of changes in the physical or biological features of the sites.

Data used to characterize and monitor the key features of, and activities carried out at, the various sites are collected by researchers carried voluntarily by expedition tour ships at selected times each austral spring and summer. In 1999, further analysis of these data was also supported by a grant from the U.S. EPA. Site visits and aerial photodocumentation also have been conducted by project personnel placed, with the assistance of the United Kingdom's Foreign and Commonwealth Office, aboard the British Royal Navy ice patrol vessel HMS *Endurance*.

Three general categories of data and information are collected: 1) basic site information on latitude and longitude, topographic features, and locations of seal haul-outs, bird colonies, etc. used to describe the sites; 2) variable site information and data used to document seasonal and annual changes in environmental conditions (e.g., sea ice extent, cloud cover, snow cover, air temperature, wind direction and speed), biological variables (e.g., number of nesting birds, numbers of eggs and chicks per nest, and number of chicks surviving to fledging), and evidence of visitor presence (e.g., footprints or paths, cigarette butts, film canisters, and other litter); and 3) maps and photodocumentation used to establish visual records of the major features of each site, particularly the locations and extent (boundaries) of bird colonies, seal colonies, and plant assemblages. Biological/demographic are collected in accor-

dance with the *CEMP Standard Methods for Monitoring Studies* (Scientific Committee for the Conservation of Antarctic Marine Living Resources, 1997), which is the standard methodology used throughout the Peninsula.

From January 1994 to February 2000, project personnel made 287 trips to 59 sites in the Peninsula area visited by ship-borne tourists. Basic descriptions of more than 50 sites have been provided in a report, entitled "Compendium of Antarctic Peninsula Visitor Sites," submitted to the governments of the United States and the United Kingdom in November 1997.

The project has begun focusing its data collection effort at heavily visited and potentially sensitive sites, and has embarked on initiatives to ensure that these data are fully comparable with data/results collected elsewhere in the Peninsula. There are 16 sites Inventory researchers attempt to census each season, at key times for collecting relevant biological/demographic data: Hannah Point, Penguin Island, Baily Head, Aitcho Island, Turret Point, Yankee Harbor, Paulet Island, Brown Bluff, Waterboat Point, Point Lockroy, Orne Islands, Georges Point, Neko Harbor, Gourdin Island, Pléneau Island, and Petermann Island. More details on this program are provided in Attachments 15 and 16¹.

The AMLR Program. Fisheries began to develop in the seas around Antarctica in the 1960s. Concern that these fisheries, particularly the fishery for Antarctic krill (*Euphasia superba*), a key component in the diets in many whale, seal, bird, and fish species, could adversely affect these species as well as the target krill stocks led the Antarctic Treaty Consultative Parties to adopt the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). The objectives of the Convention, which entered into force in 1982, are 1) to prevent harvested populations from being reduced or maintained below their maximum net productivity levels, 2) to maintain the ecological relationships among harvested, dependent, and related populations, and 3) to minimize the risk of changes in the Antarctic marine ecosystem that are not potentially reversible in two or three decades, i.e., to maintain the fullest possible range of management options for future generations.

The Antarctic Marine Living Resources Convention Act of 1984 provides the legislative authority necessary for the United States to implement the Convention. Among other things, the Act directs the Secretary of Commerce, in consultation with the Secretary of State, the Director of the National Science Foundation, and appropriate officials of other

¹ Details described in Attachment 15 were published, post-workshop, in two papers: "Censuses of penguin, blue-eyed shag, and southern giant petrel populations in the Antarctic Peninsula region, 1994–2000," *Polar Record* 36 (199): 323-334, 2000; and "Zodiac Landings by tourist ships in the Antarctic Peninsula, 1989–99," *Polar Record* 37 (201): 121-132, 2001.

federal agencies, such as the Marine Mammal Commission, to design and conduct a directed research program to support effective implementation of the Convention. The Secretary of Commerce delegated responsibility for designing and conducting the program to the National Marine Fisheries Service, which in turn has assigned responsibility to its Southwest Fisheries Science Center in La Jolla, California.

The principal elements of this program, known as the Antarctic Marine Living Resources (AMLR) Research Program, are 1) ship-board studies to document and monitor changes and trends in krill distribution, abundance, age structure, and related oceanographic conditions in the area around the South Shetland Islands, particularly the waters around Elephant, King George, and Livingston Islands; 2) trawl surveys to document and monitor the distribution, abundance, and trends of bottom fish in the waters around the South Shetland and South Orkney Islands; 3) compilation and assessment of catch and related data concerning crab and any other fisheries conducted in the Convention Area by vessels under U.S. jurisdiction; and 4) land-based studies of penguins and seals that could be affected indirectly by krill harvesting in the area around the South Shetland Islands. Additional land-based studies of penguins are carried out cooperatively with National Science Foundation grantees on Torgersen Island adjacent to Palmer Station on Anvers Island, and at Admiralty Bay on King George Island.

Since 1996, shipboard studies have been conducted during austral summers aboard the Russian research vessel, R/V *Yuzhnoye*, chartered by the National Marine Fisheries Service. The land-based studies initiated in 1988 at Seal Island, off the northwest coast of Elephant Island, were transferred in 1998 to Cape Shirreff on Livingston Island.

The study site at Cape Shirreff has been designated as a CCAMLR Ecosystem Monitoring Program (CEMP) site, and a Site of Special Scientific Interest. The studies being done there will provide data that can be used to help interpret the data being collected opportunistically from other sites as part of the Antarctic Site Inventory described above. The data being collected include that necessary to 1) estimate annually the size and productivity of the penguin and seal colonies at the site, 2) document seasonal and annual changes in the diets and at-sea foraging locations of the penguins and seals resident in the area during the summer breeding season, and 3) relate changes in the size and productivity of the penguin and seal colonies to the availability of key prey species in adjacent waters during the breeding season.

The Palmer LTER. The Long-Term Ecological Research Program at Palmer Station, initiated in 1991, is one of a series of Long-Term Ecological Research Programs being funded by the National Science Foundation. The central tenet of the program is that the annual advance and retreat of sea ice is a major determinant of temporal and spatial vari-

ability in the structure and function of the Antarctic marine ecosystem, from total annual primary production to breeding success in sea birds. Areas of research include documenting the interannual variability of annual sea ice and the corresponding variability in nutrient availability and in primary and secondary productivity; monitoring the distribution, abundance, and recruitment of krill and the breeding success and survival of sea birds in the study area; and construction and validation of models that relate ecosystem processes to environmental variability.

The study area is on the west side of the Antarctic Peninsula, and includes two sampling grids: a regional grid extending approximately 200 km offshore from Marguerite Bay in the south to the South Shetland Islands in the north, where it overlaps with the at-sea sampling grid for the AMLR Program; and a finer-scale sampling grid in the area immediately adjacent to Palmer Station.

Scientists from a broad range of scientific disciplines and academic institutions participate in the program. The institutions include the University of California at San Diego and Santa Barbara, Montana State University, SCRIPPS Institution of Oceanography, the University of Hawaii at Manoa, and the Lamont-Doherty Earth Observatory.

Additional information concerning the Palmer LTER can be found at <http://www.ices.ucsb.edu//lter/lter.html>. Among other things, the data and models being developed by the LTER Program should be useful for determining whether any changes detected in the sites in the Peninsula area being visited by ship-borne tourists are due to natural variability.

The Palmer Station Penguin Research. Adélie Penguins in the Palmer Station area occupy eight island rookeries that during the mid-1970s contained approximately 40,000 breeding pairs. Today fewer than 20,000 breeding pairs remain. A major focus of the research on Adélie Penguins in the area has been to understand the causal mechanisms associated with the decline of these populations, including the possible effects of tourism and scientific activities. The latter has been facilitated by the fact that some rookeries (Torgersen Island) have been visited by tourists and researchers for nearly three decades, while in others (Litchfield, Humble, Christine, Cormorant, Dream, Biscoe and Casey) exposure to human activity has been limited. This has provided a unique, long-term experimental setting to examine the relative effects of natural vs. human-induced variability on Adélie Penguin populations.

Recent findings, which incorporate long-term studies on breeding biology, foraging ecology and demography, suggest that most of the variability associated with the decline in Adélie Penguins can be explained by the effects of climate warming on two scales of processes. A change in the frequency of cold years with heavy winter sea ice, for example, is the factor most clearly correlated with these declines at regional scales. At local scales, however, additional processes take effect, and these can

be linked to interactions between breeding habitat geomorphology and changing patterns of snow deposition. A key implication of the latter observation in particular is that the availability and quality of the nesting habitat is an important additional source of local variability in penguin populations. This suggests that by understanding how variability in the landscape affects demography, it may be possible to tease apart the potential effects of human activity. Efforts to examine these interactions in the Palmer Station area have led to the following conclusions:

1. Studies that do not consider a potential landscape effect on Adélie Penguin demography are not likely to yield data useful for assessing the impacts of human activity associated with tourism, research or commercial fishing.
2. Tourism has not had a measurable impact on Adélie Penguin populations in the Palmer Station area.
3. Some types of research, and particularly research that requires repeated measurements based on invasive techniques such as serial blood sampling, conflict with efforts to minimize human impacts on Adélie Penguin populations.

9. LESSONS LEARNED FROM OTHER RESEARCH

Weddell Seal Research in the Ross Sea. The Weddell Seal population in the McMurdo Sound area of the Ross Sea has been studied since the early 1960s. Since 1973, all pups born in the area have been tagged. This has created a population of known-aged individuals that, aside from its value in documenting population demography, has assisted in designing and interpreting the results of physiological, genetics, and behavioral studies. The Weddell Seal's life history pattern is tailored for such studies, since the animals are philopatric, often returning to the same pupping and breeding colony each year. Thus, individual life histories can be recorded over time and a history of individual exposure to human disturbance can be documented in the database.

Over the years, individuals in this population have been handled for the attachment of tags and remote sensing devices, to take blood samples for physiology and genetic studies, and in the course of other investigations where manipulation of individuals for experimental purposes was necessary. In preparation for this workshop, the database was examined by Dr. Donald Siniff, University of Minnesota, to look for evidence of possible disturbance-related effects on the population, particularly possible effects of blood sampling which can be a very disruptive activity.

In the analysis, several possibilities were examined. The annual return rate to colonies of animals from which blood samples had been taken was contrasted with return rates for animals that had not been